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2925

**Study of Transmission and Scattering of
Gamma-Rays Through Some Materials**

THESIS

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To

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Abstract

Mass attenuation coefficients μ/ρ (cm^2/g) of some compounds and elements have been very accurately measured by using an extremely-narrow-collimated-beam transmission method. The effect of absorber position, collimation solid angle and the sample thickness on the measured mass attenuation coefficient at three different gamma ray energies (59.54, 661.6 and 1332.5 keV), have been studied .

Mass attenuation coefficients, effective atomic numbers, electron densities and total atomic cross sections for some HC (Hydrogen-Carbon), HCO (Hydrogen-Carbon-Oxygen) and HCON (Hydrogen-Carbon- Oxygen-Nitrogen) compounds (with different Hydrogen weight fraction F_h) have been measured. The experimental results of the mass attenuation coefficients are in agreement with the the theoretically calculated values. A linear relation between the mass attenuation coefficient and F_h (the hydrogen weight fraction) in HC compounds was obtained. From this relation the hydrogen weight fraction of paraffin wax was determined as 20.11 % and its effective molecular structure can be written as ($\text{C}_2 \text{H}_6$).

Absolute values of coherent plus incoherent differential scattering cross sections of the 59.54 keV gamma ray of ^{241}Am from Anthracene, POPOP, Polystyrene and Paraffin were experimentally determined for ten scattering angles between 30° and 120° . The corresponding theoretical differential cross sections were calculated by means of form factors and incoherent scattering functions. A comparison between the experimentally determined results and the

theoretically calculated values shows good agreement, when the theoretical calculations of the atomic form factors and incoherent scattering functions were based on the summation of the individual form factors and incoherent scattering functions of their constituent elements in the molecule according to the number of atoms in the molecule.

The total (coherent plus incoherent) atomic differential scattering cross sections of 59.54 keV γ - rays from Ni, Ag, Ca, Ta, and W between 40° and 120° have been measured. The corresponding theoretical values were also calculated.

The coherent differential atomic cross sections have been computed from the experimentally determined total differential atomic cross section by subtracting the calculated incoherent differential atomic cross section. The obtained values coincided to a great extent with the published data.

Differential Compton scattering cross section of the 661.6 keV gamma rays of ^{137}Cs from twelve HC and HCO compounds with different hydrogen weight fractions and electron densities were experimentally determined for three scattering angles (60° , 90° and 120°). The experimental results shows good agreement with the theoretically calculated values.

A linear relation has been obtained between the differential Compton scattering cross section ($d\sigma_{\text{comp}}/d\Omega \text{ cm}^2/\text{g} \cdot \text{sr}$) and the hydrogen weight fraction for HC compounds and not for the case of HCO compounds.

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Arabic Summary

PART 1

Chapter 1

INTRODUCTION AND AIM OF THE WORK

1-1. INTRODUCTION

With the increasing use of gamma active isotopes in medicine, industry and agriculture in recent time, a renewed interest has been developed in researches to study mass attenuation coefficients, effective atomic numbers, effective electron densities, and total atomic cross sections in various materials.

1-1.1. Mass attenuation coefficient

The most important quantity characterizing the penetration and diffusion of γ -radiation in extended media is the mass attenuation coefficient (μ / ρ), which depends on the photon energy (E) and the atomic number (Z) of the medium. In turn the experimental values of the effective atomic number, effective electron density and total atomic cross sections imply accurate determination of the mass attenuation coefficient.

Measurements of attenuation of photons in matter can be categorized as either broad beam or narrow beam attenuation measurements. This classification depends on the geometrical arrangement of the experiment, which would either accept or reject the scattered radiation and other secondary radiation resulting from photon interaction with the target.

The idealized narrow beam attenuation geometry can in principle be achieved by an arrangement which prevents the scattered and secondary radiations from reaching the detector, and also by discriminating against all scattered and other secondary radiations that reach the detector, on the basis of photon energy, direction, coincidence and anticoincidence etc. The broad beam attenuation occurs in the case of any geometry other than narrow beam, in which some non-primary radiation reaches the detector.

Theoretical calculations of mass attenuation coefficients for different elements and compounds for different γ -ray energies have been reported by several authors :

Hubbell [1], has compiled the photon mass attenuation and mass energy-absorption coefficients for 40 elements ranging from $Z = 1$ to $Z = 92$ and for some compounds and mixtures of dosimetric and biological importance, in the energy range 1 keV to 20 MeV.

Hubbell [2], tabulated the photon cross-sections and mass attenuation coefficients for elements with $Z = 1$ to $Z = 100$ for photon energies in the range 1 MeV to 100 GeV.

Hubbell [3], has included photon cross-section and attenuation coefficient data over the wider energy range 10 keV to 100 GeV, but for only 23 elements ranging from $Z = 1$ to $Z = 92$.

Hubbell [4], tabulated photon mass attenuation and mass energy absorption coefficients for H, C, N, O, Ar, and seven mixtures; air, water, polystyrene, methylmethacrylate, polyethylene, bakelite and amber from 0.1 keV to 20 MeV,

including ^{137}Cs and ^{60}Co energies explicitly. Cross-sections are listed for the above elements for the principal photon atom interactions.

Experimental measurements of mass attenuation coefficients for different elements and compounds for different γ -ray energies have been reported by several authors using different narrow beam geometries and selected sample thicknesses.

Davisson and Evans [5], measured the absorption of γ -ray in Al, Cu, Sn, Ta and Pb of different thicknesses using gamma-rays from ^{131}I , ^{64}Cu , ^{54}Mn , ^{60}Co , ^{65}Zn and ^{24}Na using narrow beam geomtry of a maximum angle of scattering 2.6° in which correction due to scattered radiation from nearby objects and from the absorber were negligible.

Howland [6], measured γ -ray absorption coefficients over a range of energies from 0.279 MeV to 1.113 MeV for NaI, Cu, Ta and W using an energy-selective scintillation detector with the same geometry as that of Davisson and Evans [5]. Measurements were made for the absorber position which gave the maximum absorption coefficient. According to Rudnick [7] the position of maximum absorption coefficient gives the most reliable experimental result because this position minimizes the various scattering errors.

Conner et al. [8], have measured the total γ -ray attenuation coefficients at nine energies in the range 88 keV to 2.75 MeV for 24 elements with atomic numbers ranging from $Z = 4$ to $Z = 94$, using narrow beam geomtry in which the maximum solid angle of scattering from sample to detector is less than 0.5×10^{-4} sr. Sample thickness which gives transmission ratio (I / I_0) in the range of $0.1 < I / I_0 < 0.4$ is selected.